

The NASA Centennial Challenge

For Personal Air Vehicles (PAVs)

Official Rules and Entry

The National Aeronautics and Space Administration (NASA) and the Comparative Aircraft Flight Efficiency (CAFE) Foundation announce the 2005 NASA Centennial Challenge PAV Prize Competition, whose main event shall be held at the CAFE flight test facility at Santa Rosa, California's Charles M. Schulz Airport on Saturday August 27 and Sunday August 28. This is the first of a 5-year competition that will promote the popular use of self-operated, personal aircraft for fast, safe, efficient, affordable, environmentally friendly, and comfortable on-demand transportation as a future solution to America's mobility needs. These rules are subject to change to disallow vehicles with unacceptable characteristics from exploiting the prize rules as well as to tighten the entrant threshold criteria over the life of this competition. For 2005, up to 16 competitors may apply on a first come, first-served basis. An entrant is accepted into the competition only after demonstrating the capability to meet all threshold criteria during qualifying flight tests at the CAFE flight test facility in the months well in advance of the competition date.

Prizes:

The PAV Prize will award a total yearly prize purse of \$250,000. This purse will be awarded as one PAV Vantage Prize of \$150,000 and five Outstanding Achievement Prizes (OAPs). To assure that competitors' aim for a balance in the diverse capabilities that are appropriate to America's future mobility needs, the OAPs will each reward the competitor that demonstrates the best performance in a particular category while meeting all other rules and thresholds of performance required in the competition. The OAPs are intended to spur progress in each of the following categories: Community Noise Reduction (\$25,000) Cabin Noise Reduction (\$25,000), Handling Qualities (\$25,000) and Ease of Use (\$25,000).

- 1) The PAV Vantage Prize (\$150,000): Awarded to the competitor that demonstrates the best combination of overall door-to-door trip velocity, energy consumption and passenger carrying capability while meeting all other threshold requirements of the competition. The PAV Vantage Prize is awarded to the competitor with the highest score as computed by the following formula:

$$\text{Velocity}^{1.3} \times \text{MPG} \times \text{Payload}^{0.6}$$

- 1a) The Velocity in mph is calculated from the competitor's average speed over a 300 mile prescribed demonstration course modified by an accounting of any extra ground leg travel and delay time necessary to go from the air vehicle to a simulated destination "doorway". Ground leg times will be allocated according to the demonstrated runway distance class of the vehicle. The runway distance class of each vehicle will be determined by measuring both the takeoff and landing distance of the vehicle. The longer of takeoff or landing distance will determine the vehicle's runway distance class.

The runway distance classes are: CTOL or “conventional takeoff and landing, STOL or “short takeoff and landing”, ESTOL or “extremely short takeoff and landing” and VTOL or “vertical takeoff and landing”. The ground leg times will be assigned as follows:

- i. CTOL: 25 miles at 35 mph plus 15 minute delay time. (57.86 minutes extra time)
- ii. STOL: 2.5 miles at 35 mph plus 15 minute delay time. (19.28 minutes extra time)
- iii. ESTOL: 0.25 miles at 35 mph plus 15 minute delay time. (15.43 minutes extra time)
- iv. VTOL: 0.025 miles at 4 mph and 1 minute delay time. (4.75 minutes extra time)

Runway distance classes: The runway distance class will be determined by measuring both the takeoff and landing distance of the vehicle. The landing distances will be measured using a virtual Runway In The Sky flight data recorder that allows landing simulations at altitudes thousands of feet above the ground. These distances will be converted to the FAA definitions of “Balanced Field Length” for takeoff and “FAR Landing Distance”. The longer of these will determine the vehicle’s runway distance class.

The Balanced Field Length is defined as the distance from brake release to clearing a 35 foot obstacle on takeoff. The FAR Landing Distance is defined and the actual landing distance over a 50 foot obstacle times 5/3 or 1.667. All vehicles must demonstrate FAR Landing Distance and Balanced Field Length of less than 2700 feet while at gross weight.

For 2005, the Runway distance classes shall be as follows:

CTOL: the greater of FAR Landing Distance or Balanced Field Length = 900 to 2700 feet.

STOL: the greater of FAR Landing Distance or Balanced Field Length = 300 to 900 feet.

ESTOL: the greater of FAR Landing Distance or Balanced Field Length = 100 to 300 feet.

VTOL: the greater of FAR Landing Distance or Balanced Field Length = 0 to 100 feet.

1b) MPG is calculated from the competitor’s demonstrated average miles per gallon of fuel over a 300 mile prescribed course and an accounting of any extra ground travel fuel necessary to go from the aircraft to a simulated destination “doorway”. All ground travel fuel consumption will be set at 30 mpg for computation purposes. Accordingly, ground fuel use will be categorized by runway distance class, as follows:

- i. CTOL: 0.83 gallons
- ii. STOL: 0.083 gallons
- iii. ESTOL: 0.0083 gallons
- iv. VTOL: zero gallons

1c) Payload is the actual cabin payload in non-fuel weight that is carried over a 300 mile prescribed course and shall not exceed 250 pounds per available seat.

2) PAV Community Noise Prize (\$25,000): Awarded to the competitor with the lowest noise radiated into the community. The two measuring points (to be averaged) are a point 1125 feet MSL (1000 feet AGL) directly below a full power, level overflight and a point located sideways from the vehicle’s full power takeoff brake release point at a distance determined by the vehicle’s runway distance class. All measurements will be made in dBA (slow scale).

3) PAV Cabin Noise Prize (\$25,000): Awarded to the competitor with the lowest cabin noise level. Noise is measured in dBA, slow scale, at the right ear of the pilot during full-power stabilized level overflight at 1125 feet MSL.

- 4) PAV Handling Qualities Prize (\$25,000): Awarded to the competitor judged best on the Cooper-Harper rating scale for a selected set of essential flying and handling qualities.
- 5) PAV Ease of Use Prize (\$25,000): Awarded to the competitor judged easiest to operate overall. This is an inherently subjective evaluation that will take into account things such as complexity, ease of entry, ease of starting, flight deck design and layout, manual forces required, pilot workload, field of view, how hard is it to stow baggage, is center of gravity range adequate for carefree loading, etc.

The following set of entrant requirements and threshold performance criteria must be demonstrated before an aircraft will be accepted into the competition:

Entrant Requirements:

- 1) All competing vehicles must fly and be licensed as airworthy by the Federal Aviation Administration (FAA).
- 2) All competitors that are roadable must comply with all Department of Transportation (DOT) regulations for mass-produced vehicles of its type (automobile, motorcycle, DOT section 500).
- 3) Nothing may be jettisoned from the vehicle at any time.
- 4) The vehicle must be equipped for night operation. (IFR in year 3)
- 5) If vehicle is roadable, the ground leg transportation mode must provide reasonable comfort during all weather operation (rain, snow, wind).
- 6) Miles Per Gallon (MPG) is used as a familiar measure of energy consumption to cover a given distance. In the event that a competitor does not use gasoline, an equivalent MPG will be calculated, based on energy consumed during the demonstration flight and the energy content of a gallon of gasoline.

Threshold Performance Criteria:

- 1) Community Noise: Competitors must emit no more than 72 dBA at a point located sideways from the full-power takeoff brake release point. Competitors that are unable to meet the noise limits of their runway distance class will have to accept the intermodal time penalties and fuel penalties of the whatever greater sound distance category they can meet. The distance to the sound measuring point depends upon the runway distance class as follows:

CTOL: 1000 feet sideways from brake release point.
STOL: 500 feet sideways from brake release point
ESTOL: 250 feet sideways from brake release point
VTOL: 125 feet sideways from brake release point
- 2) Cabin Noise: Competitor must not exceed 92 dBA as measured on the 'slow' scale, at the right ear of the pilot during full-power, stabilized level overflight at 1125 feet MSL.

- 3) Handling Qualities: Competitors must achieve at least Cooper-Harper level 2 ratings for all flight tasks selected for testing. The tasks will include static longitudinal stability, maneuvering stability, spiral stability, stall characteristics and takeoff and landing characteristics.
- 4) The vehicle must have usable and comfortable seat accommodations for between two and six occupants and each seat, to be credited as a seat, must meet all of the following criteria for loading:
 - a) Must comfortably accommodate a 6 feet tall, 180 pound person with seatbelt+harness for same.
 - b) Must include a space, load and c.g. range adequate for 20 pounds of airline standard carry on baggage.
 - c) Must meet requirements 6a and 6b when all other seats are likewise loaded to 180 + 20 lb.

In addition, the vehicle must meet all other rules of the competition with all credited seats fully loaded with the equivalent of 180 lb plus 20 lb of baggage and with fuel adequate for 300 miles range. The payload credit in the PAV Prize will be limited to a maximum of 200 pounds per credited seat and will be the actual number of (non-fuel) cabin payload pounds carried during the performance flight. During all flights, the vehicle's takeoff gross weight and center of gravity envelope must be adequate to accommodate the load carried.

- 5) A pilot weighing between 90 and 220 pounds must be able to fly the vehicle solo from the pilot's seat without ballast and with fuel tanks both empty and full, while maintaining the center of gravity with acceptable limits.
- 6) Acceleration Limits:
 - a) Maximum axial acceleration on takeoff is 0.5 g.
 - b) Maximum axial deceleration on landing is 0.2 g.
 - c) Maximum vertical acceleration on takeoff or landing is +0.5, -0.2
- 7) Each vehicle must demonstrate a maximum FAR Landing Distance and Takeoff Balanced Field Length of less than or equal to 2700 feet.
- 8) Demonstrated landing configuration stall speed shall be less than 52 mph CAS at gross weight.
- 9) Average rate of climb between 2500 and 3500 feet MSL must be greater than 400 feet per minute, corrected to standard day atmospheric conditions.
- 10) Minimum range when loaded with a non-fuel payload of 200 lb per seat must be more than 300 miles.
- 11) After engine start, there must not be appreciable visible smoke emitted at any time.
- 12) Ground leg transportation mode must provide reasonable comfort during all weather operation (rain, snow, wind).
- 13) Cruise speed at or above 5000 feet MSL must be at least 130 mph TAS. Prequalification needed.
- 14) Measured trip average fuel economy while carrying 200 lb per seat must be at least:

27.5 MPG if 2 seats - 21.3 MPG if 3 seats
18.3 MPG if 4 seats - 16.4 MPG if 5 seats
14.5 MPG if 6 seats